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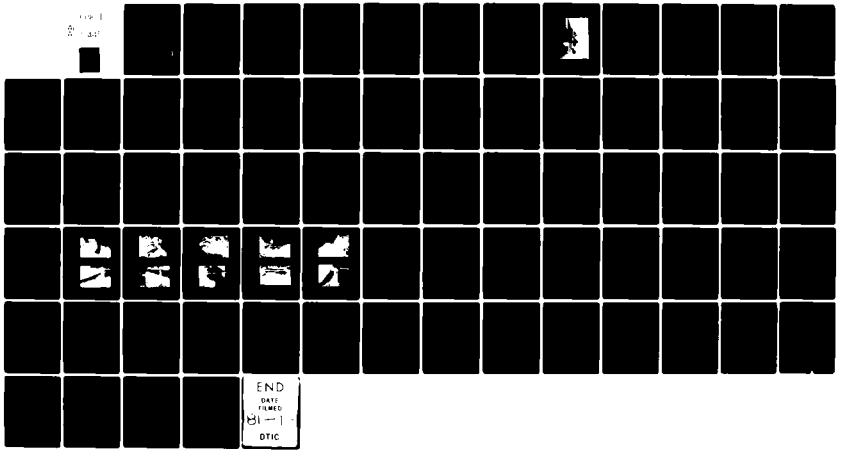

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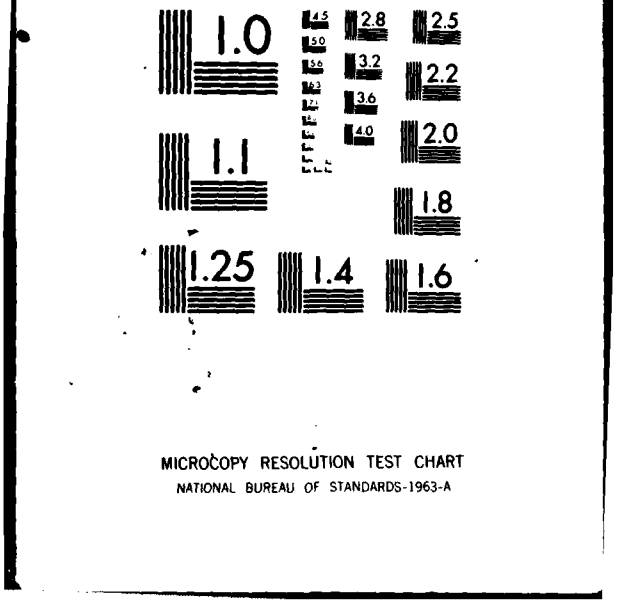
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DELAWARE RIVER BASIN
TRIBUTARY TO LEHIGH RIVER, WAYNE COUNTY

PENNSYLVANIA

LAKE WATAWGA DAM

NDI ID NO. PA-00098
DER ID NO. 64-38

LAKE WATAWGA HOLDING CORPORATION

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DAC W 31-80-C-0017

Prepared by
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
Consulting Engineers
Harrisburg, Pennsylvania 17105

For
DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

JULY 1980

DELAWARE RIVER BASIN

TRIBUTARY TO LEHIGH RIVER, WAYNE COUNTY

PENNSYLVANIA

(6) National Dam Inspection Program.

LAKE WATAWGA DAM

(NDI ID ~~No.~~ Number PA-~~00~~098,
DER ID ~~No.~~ Number 64-38), Delaware River Basin,
~~LAKE WATAWGA HOLDING CORPORATION~~ Tributary To
Lehigh River, Wayne County,
Pennsylvania.

PHASE I INSPECTION REPORT,

NATIONAL DAM INSPECTION PROGRAM

(15) Fred. Inst. Rpts.

(11) [illegible]-80-C-0017

Prepared by

GANNETT FLEMING CORDDRY AND CARPENTER, INC.
Consulting Engineers
P.O. Box 1963
Harrisburg, Pennsylvania 17105

For

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

DELAWARE RIVER BASIN

TRIBUTARY TO LEHIGH RIVER, WAYNE COUNTY

PENNSYLVANIA

LAKE WATAWGA DAM

NDI ID No. PA-00098
DER ID No. 64-38

LAKE WATAWGA HOLDING CORPORATION

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JULY 1980

CONTENTS

APPENDICES

Cer Item 50

A

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

BRIEF ASSESSMENT OF GENERAL CONDITION

AND

RECOMMENDED ACTION

Name of Dam:	Lake Watawga Dam NDI ID No. PA-00098 DER ID No. 64-38
Size:	Small (12 feet high; 654 acre-ft)
Hazard Classification:	High
Owner:	Lake Watawga Holding Corporation W. Paul Moyer, President R.D. 4 Doylestown, Pa. 18901
State Located:	Pennsylvania
County Located:	Wayne
Stream:	Tributary to Lehigh River
Date of Inspection:	3 June 1980

Based on criteria established for these studies, Lake Watawga Dam is judged to be unsafe, nonemergency, because the spillway capacity is seriously inadequate. The recommended Spillway Design Flood (SDF) for the size and hazard classification of the dam varies from 1/2 the Probable Maximum Flood (PMF) to the PMF. Based on the criteria and the downstream conditions, the selected SDF is the PMF. Based on existing conditions, the spillway will pass about 14 percent of the PMF before overtopping of the dam occurs. It is judged that the dam would fail during the PMF. Failure of the dam would increase the hazard for loss of life downstream.

As a whole, the dam is judged to be in fair condition. Deficiencies exist that are considered to be

indicative of potential stability problems for the spillway. There is no functional outlet works at the dam. Maintenance at the dam is inadequate.

The following studies and remedial measures are recommended to be undertaken by the Owner, in approximate order of priority, immediately:

(1) Perform additional studies to more accurately ascertain the spillway capacity required for Lake Watawga Dam as well as the nature and extent of measures required to provide adequate spillway capacity. Take appropriate action as required.

(2) Perform additional studies as required to determine whether any potential hazard to stability exists for the spillway.

(3) Take action as required to provide a functional outlet works at the dam.

(4) Design and construct repairs for the deteriorated areas of the various structures.

(5) Remove brush and trees growing on and near the embankment.

All investigations, studies, designs, and inspection of construction should be performed by a professional engineer experienced in the design and construction of dams. Tree removal should also be performed under the guidance of a professional engineer.

In addition, the Owner should institute the following operational and maintenance procedures:

(1) Develop a detailed emergency operation and warning system for the dam.

(2) During periods of unusually heavy rains, provide round-the-clock surveillance of the dam.

(3) When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system.

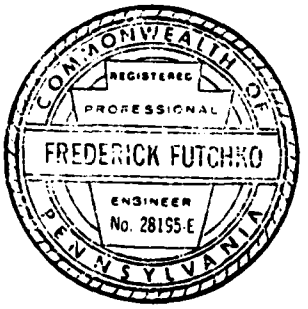
(4) Initiate an inspection program such that the dam is inspected on a regular basis. As presently required by

the Commonwealth, the inspection program should include a formal annual inspection by a professional engineer experienced in the design and construction of dams. Utilize the inspection results to determine if remedial measures are necessary.

(5) Institute a maintenance program so that all features of the dam are properly maintained.

Submitted by:

GANNETT FLEMING CORDDRY
AND CARPENTER, INC.



FREDERICK FUTCHKO
Project Manager, Dam Section

Date: 8 August 1980

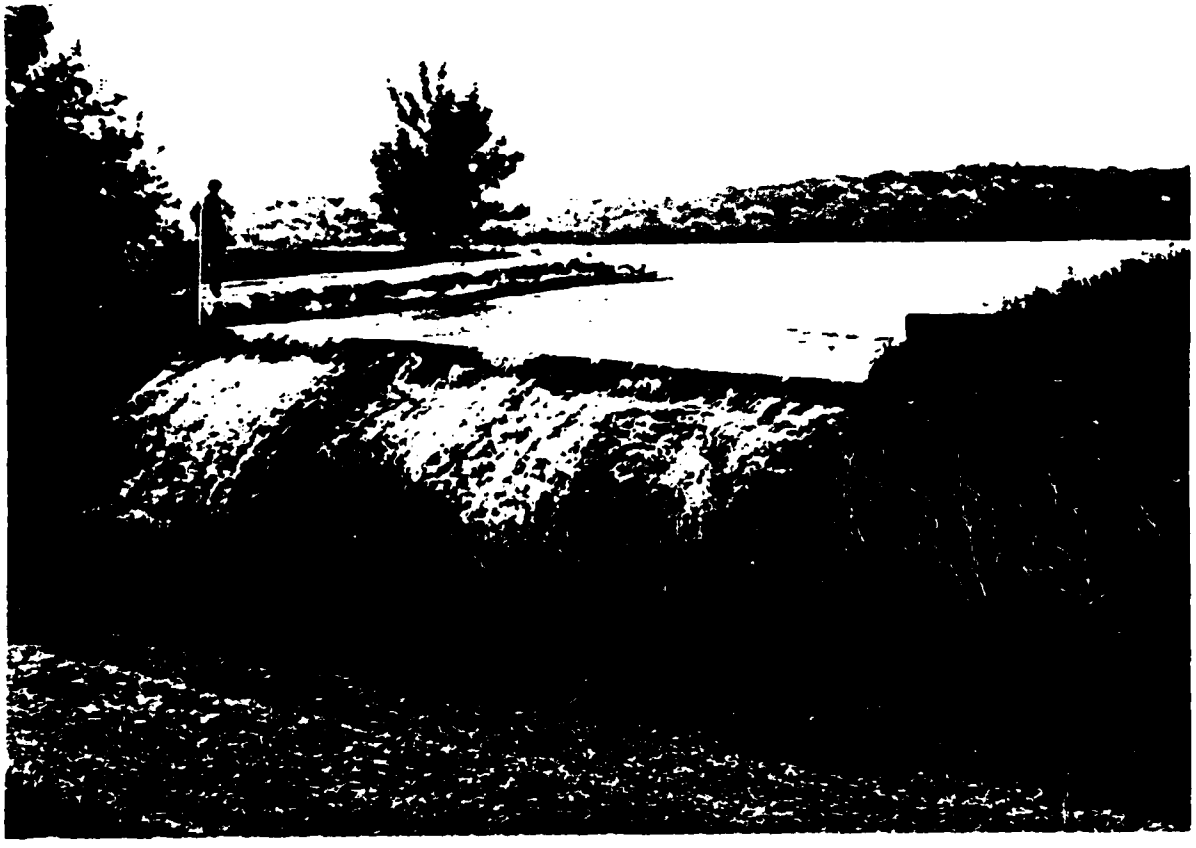
Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF
ENGINEERS

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

Date: 2 Sep 1980

LAKE WATAWGA DAM



Overview

DELAWARE RIVER BASIN

TRIBUTARY TO LEHIGH RIVER, WAYNE COUNTY

PENNSYLVANIA

LAKE WATAWGA DAM

NDI ID No. PA-00098
DER ID No. 64-38

LAKE WATAWGA HOLDING CORPORATION

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

JULY 1980

SECTION 1

PROJECT INFORMATION

1.1 General.

a. Authority. The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose. The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project.

a. Dam and Appurtenances. Lake Watawga Dam is an earthfill dam with a concrete corewall. The dam is 12 feet high at its maximum section and about 165 feet long, including the spillway.

The spillway is located at the highest section of the dam. The corewall of the dam acts as the weir. A concrete apron is located just downstream from the weir, and a stone masonry wall is at the downstream end of the apron. The crest length of the spillway is 51 feet, and the crest is 1.6 feet lower than the top of the dam.

There is no functional outlet works at the dam.

The various features of the dam are shown on the Photographs in Appendix C and on the Plates in Appendix E. A description of the geology is included in Appendix F.

b. Location. Lake Watawga Dam is located on an unnamed tributary to the Lehigh River in Lehigh Township, Wayne County, Pennsylvania, approximately 0.4 mile east of Gouldsboro. Lake Watawga Dam is shown on USGS Quadrangle, Tobyhanna, Pennsylvania, at latitude N 41° 14' 20" and longitude W 75° 26' 40". A location map is shown on Plate E-1.

c. Size Classification. Small (12 feet high, 654 acre-feet).

d. Hazard Classification. High hazard. Downstream conditions indicate that a high hazard classification is warranted for Lake Watawga Dam (Paragraphs 3.1e and 5.1c (5)).

e. Ownership. Lake Watawga Holding Corporation, W. Paul Moyer, President, R.D. 4, Doylestown, Pennsylvania 18901.

f. Purpose of Dam. Recreation.

g. Design and Construction History. Almost nothing is known about the design and construction of Lake Watawga Dam. Available data indicate that it was built about 1907 and reconstructed in 1915 by the Gouldsboro Ice Company. The reasons for and the extent of the reconstruction are unknown. Fill material was added to both the upstream and downstream sides of the dam at unknown times. As a result of the fill placement and site grading, the original lines and grades of the dam have been obscured. After the August 1955 Flood, minor repairs were made to a spillway wingwall. In 1970, plans for rehabilitation of the corewall and the spillway sidewalls were prepared by F. C. Shoenagel, Jr., Civil Engineer. Although work was later undertaken, it was not in accordance with the design proposed in 1970.

h. Normal Operational Procedure. The pool is maintained at the spillway crest level with excess inflow discharging over the spillway. Spillway discharge flows downstream to the confluence with the Lehigh River.

1.3 Pertinent Data.

a.	Drainage Area. (square miles)	2.57
b.	Discharge at Damsite. (cfs.)	
	Maximum known flood at damsite	August 1955 flood. Discharge unknown.
	Spillway capacity at maximum pool elevation	320
c.	Elevation. (feet above msl.)	
	Top of Dam (by field survey)	1921.6
	Maximum pool	1921.6
	Normal pool (spillway crest)	1920.0
	Streambed at toe of dam	1909.4
d.	Reservoir Length. (miles)	
	Normal pool	0.51
	Maximum pool	0.53
e.	Storage. (acre-feet)	
	Normal pool	442
	Maximum pool	654
f.	Reservoir Surface. (acres)	
	Normal pool	125
	Maximum pool	140
g.	Dam.	
	Type	Earthfill with concrete corewall.
	Length (feet)	165
	Height (feet)	12
	Topwidth (feet)	Varies
	Side Slopes	
	Upstream	Varies
	Downstream	Varies
	Zoning	Unknown.

g.	Dam. (cont'd.) Cut-off	Unknown.
	Grout Curtain	Unknown.
h.	Diversion and Regulating Tunnel.	None.
i.	Spillway. Type	Concrete weir.
	Length of Weir (feet)	51.0
	Crest Elevation	1920.0
	Upstream Channel	Reservoir.
	Downstream Channel	Concrete apron and free overfall.
j.	Regulating Outlets.	None functional.

SECTION 2

ENGINEERING DATA

2.1 Design.

a. Data Available. There are no design data available for Lake Watawga Dam.

b. Design Features. The project is described in Paragraph 1.2a. The various features of the dam are shown on the Photographs in Appendix C and on Plate E-2 in Appendix E. The embankment is shown on Photographs A through E. The spillway is shown on Photographs F through J.

c. Design Considerations. The design of the dam cannot be assessed from available data.

2.2 Construction.

a. Data Available. There are no construction data available for Lake Watawga Dam.

b. Construction Considerations. The construction of the dam cannot be assessed from available data.

2.3 Operation. There are no formal records of operation. Records of inspections performed by the Commonwealth are available for the period from 1919 to 1969. The inspection reports indicate that some deficiencies have developed over the life of the dam. A summary of these inspections is included in Appendix A.

2.4 Evaluation.

a. Availability. Engineering data were provided by the Bureau of Dams and Waterway Management, Department of Environmental Resources, Commonwealth of Pennsylvania (PennDER). The Owner and the Owner's engineer were available for information during the visual inspection.

b. Adequacy. The type and amount of available design data and other engineering data are limited, and the assessment must be based on the combination of available data, visual inspection, performance history, hydrologic assumptions, and hydraulic assumptions.

c. Validity. There is no reason to question the validity of the available data.

SECTION 3

VISUAL INSPECTION

3.1 Findings.

a. General. The overall appearance of the dam is fair. Deficiencies were observed as noted below. A sketch of the dam with the locations of deficiencies is presented on Exhibit B-1 in Appendix B. Survey information acquired for this Report is summarized in Appendix B. On the day of the inspection, the pool was 0.1 foot above spillway crest.

b. Embankment. The top of the dam is covered with grass (Photograph A). The portion to the left of the spillway is not cut regularly, but the portion to the right of the spillway is used as a lawn area for an adjacent dwelling. The concrete corewall protrudes above the top of the embankment (Photographs A, B, and C). The height of the corewall above the embankment varies from zero to about one foot. There is fill material on the upstream side of the corewall (Photographs B and C). At each side of the spillway, the fill is near the top of the corewall. Along the spillway, the fill is about 5 feet lower than the top of the corewall. The exposed portion of the corewall is in fair condition. There are some small cracks that extend across its top, and there are areas of local deterioration on its upstream face.

The upstream slope of the dam has only a limited amount of slope protection, but there was no evidence that indicated a serious erosion problem. The angle of the upstream slope could not be measured during the inspection.

The downstream slope of the embankment to the left of the spillway is approximately 1V on 4H (Photograph D). The downstream slope to the right of the spillway varies from approximately 1V on 4H to approximately 1V on 10H (Photographs E and F). There are minor amounts of brush at various locations on the embankment. One large tree is growing near the toe just to the right of the spillway (Photograph E). No seepage was observed along the toe of the embankment on the day of the inspection.

c. Appurtenant Structures. The corewall section that acts as the spillway weir is in good condition. The concrete apron slab is cracked at several locations (Photographs F, G, and H). Differential vertical movement has occurred at some cracks, up to a maximum of 3/4 inch. At the downstream left corner of the concrete apron, a triangular piece of the slab is missing (Photograph I) and substantial amounts of water were flowing into the resulting void. Examination of the apron slab at its downstream end indicates a probable concrete thickness of about 4 inches. The sidewalls at the apron have some small cracks and minor deterioration where they meet the apron. The downstream stone masonry face of the spillway is in fair condition. No mortar is apparent between the stones. The spaces between the stones can be probed to an average depth of 6 inches. Stones were missing from the structure at two locations. At one location, the resulting void was probed to a depth of 2 feet. At the other location, near the top of the structure, the resulting void was probed to a depth of 4 feet (Photograph J). Any seepage or leakage that might exist at the toe of the spillway was obscured by the flow over the spillway on the day of the inspection. Downstream from the spillway, the right wingwall is overgrown with trees and brush and is partially collapsed.

There is no outlet works visible at the dam.

d. Reservoir Area. The watershed area is about 95 percent wooded and about 5 percent grassland. Only a minor amount of development is present. Mild, wooded slopes surround the reservoir. Swampy areas are common within the watershed.

e. Downstream Channel. A small roadway embankment and a timber bridge cross the channel about 20 feet downstream from the spillway. At a distance of 0.2 mile downstream, a public road crosses the stream. In the immediate vicinity of this crossing there are about 7 low-lying dwellings. About 0.4 mile downstream, Pa. Route 507 crosses the stream. Two dwellings are located at that area. Beyond Route 507, the tributary flows through a lake known as Snag Pond, through a reservoir known as Johnson Pond, and through another reservoir known as Westend Pond. It was estimated that about 9 dwellings would be flooded if Lake Watawga Dam were to fail.

SECTION 4

OPERATIONAL PROCEDURES

4.1 Procedure. The reservoir is maintained at the spillway crest level with excess inflow discharging over the spillway and into the downstream channel.

4.2 Maintenance of Dam. There are no established procedures for maintenance of the dam. Some maintenance work has been performed on an as-needed basis, and some portions of the embankment are maintained by adjacent property owners. The Owner stated that informal inspections are made several times each year by members of the Lake Watawga Holding Corporation.

4.3 Maintenance of Operating Facilities. There is no functional outlet works at the dam.

4.4 Warning Systems in Effect. The Owner has no emergency operating and warning system.

4.5 Evaluation of Operational Adequacy. Although some maintenance is performed, the current program is not adequate. Inspections are necessary to detect hazardous conditions at the dam. An emergency operation and warning system is necessary to reduce the risk of dam failure should adverse conditions develop and to prevent loss of life should the dam fail.

SECTION 5

HYDROLOGY AND HYDRAULICS

5.1 Evaluation of Features.

a. Design Data. There are no design data for the spillway structure. Commonwealth records list the drainage area of Lake Watawga Dam as 1.2 square miles, but the drainage area computed from recent USGS mapping and used for this study is 2.57 square miles.

b. Experience Data. Records and verbal information indicate that the August 1955 Flood, which was caused by Tropical Storm Diane, resulted in overtopping of Lake Watawga Dam. The depth and duration of overtopping are unknown. Damage was reported to be slight, consisting of erosion damage to the embankment near the spillway.

c. Visual Observations.

(1) General. The visual inspection of Lake Watawga Dam, which is described in Section 3, resulted in a number of observations relevant to hydrology and hydraulics. These observations are evaluated herein for the various features.

(2) Embankment. The lowest area on the top of the dam is at Elevation 1921.6. As shown on the profile in Appendix B, there are also overbank reaches near the dam which are at the same elevation. If the dam were to overtop, overbank flow would begin simultaneously. The effective overbank flow area is difficult to determine because of the nature of the site. Extensive regrading of the site over the years has created a large surrounding area that would require extensive mapping to determine the effective overbank flow area and flow paths. An attempt to account for the overbank flow was made for this Report, but it is only approximate because of the limitations of mapping for a Phase I Report.

(3) Appurtenant Structures. The spillway outlet channel is obstructed by a private roadway with a small, timber bridge. The roadway embankment is only about 4 feet high and would have no effect on spillway capacity.

No outlet works facilities are visible at the dam. However, records indicate that such facilities did exist at one time. A report prepared by the Pennsylvania Water Supply Commission in 1917 describes a 20-inch diameter, cast-iron pipe encased in concrete at the center of the spillway. A photograph taken in 1930 shows a gate operating mechanism located at the upstream side of the spillway. Based on applications for drawing down the lake that were submitted to the Commonwealth, it appears that the outlet works was functional at least through 1956. The current Owner of the dam had no knowledge of any outlet works facilities.

(4) Reservoir Area. No conditions were observed in the reservoir area that were considered to present a hazard to the dam.

(5) Downstream Conditions. If Lake Watawga Dam were to fail, it would cause flooding of at least 9 dwellings. It would also present a hazard to two dams located downstream. The downstream conditions indicate that a high hazard classification is warranted for Lake Watawga Dam.

d. Overtopping Potential.

(1) Spillway Design Flood. According to the criteria established by the Office of the Chief of Engineers (OCE), the Spillway Design Flood (SDF) for the size (Small) and hazard potential (High) of Lake Watawga Dam is between one-half of the Probable Maximum Flood (PMF) and the PMF. Because of the downstream conditions, the PMF is selected as the SDF for Lake Watawga Dam. The watershed was modeled with the HEC-1DB computer program. A description of the model is included in Appendix D. The assessment of the dam is based on existing conditions, and the effects of future development are not considered.

(2) Summary of Results. Pertinent results are tabulated at the end of Appendix D. The analysis reveals that Lake Watawga Dam can pass only about 14 percent of the PMF before overtopping of the dam occurs.

(3) Spillway Adequacy. The criteria used to rate the spillway adequacy of a dam are described in Appendix D. Because Lake Watawga Dam cannot pass the 1/2 PMF, a further analysis was performed. Lake Watawga Dam was judged to fail during an occurrence of the 1/2 PMF. Criteria concerning the mode of failure are included in Appendix D. It was found that failure of the dam would

cause water levels at the dwellings to rise 2.3 feet above the levels that would exist if the dam were not to fail. There is an increased hazard for loss of life; the spillway capacity of Lake Watawga Dam is rated as seriously inadequate.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability.

a. Visual Observations.

(1) General. The visual inspection of Lake Watawga Dam, which is described in Section 3, resulted in a number of observations relevant to structural stability. These observations are evaluated herein for the various features.

(2) Embankment. The embankment slopes are relatively flat. There was no seepage apparent, and there were no apparent stability problems. The exposed portions of the corewall are in fair condition, but there are some areas of local deterioration. The growth of trees and brush on the dam is undesirable. Root systems can loosen embankment material and eventually create paths along which seepage and piping (internal erosion) might occur.

(3) Appurtenant Structures. The condition of the spillway apron is of concern. The combination of cracks with differential movement and possible voids under the slab could be indicative of potentially serious problems. The type of material underlying the apron slab is unknown. If the foundation material is erodible, the stability of the spillway could be threatened. Available records indicate that the cracks developed as early as 1965, but the records do not indicate whether differential movement had occurred by that time.

The mortar of the stone masonry wall at the downstream end of the spillway apron has deteriorated over the years. Photographs from 1917 and 1930 show mortar, but very little exists now. Whether or not this is a potential hazard cannot be evaluated because there are no design or construction data for the spillway structure. Any leakage that might exist through this wall was obscured by spillway flow on the day of the inspection.

The stone masonry wingwall along the right side of the spillway outlet channel is damaged and overgrown with trees and brush. Since this wall protects a portion of the embankment, its integrity is important to the safety of the dam.

b. Design and Construction Data. There are no design or construction data for the dam or appurtenant structures. A proposed plan for rehabilitation of the corewall and spillway walls was prepared in 1970, but work that was actually performed was not in accordance with the plan.

c. Operating Records. There are no formal records of operation. Based on available data, no stability problems are reported to have occurred over the operational history of the dam.

d. Post-construction Changes. Post-construction changes include site regrading and minor repairs to the corewall and spillway. The site regrading resulted in flatter slopes on the dam, which have a favorable effect on stability.

e. Seismic Stability. Lake Watawga Dam is located in Seismic Zone 1. Earthquake loadings are not considered to be significant for small dams located in Zone 1 when there are no readily apparent stability problems at the dam. However, since potential structural deficiencies were observed for the spillway, the stability under earthquake loadings cannot be assumed to be adequate.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment.

a. Safety.

(1) Based on available records, visual inspection, and past operational performance, Lake Watawga Dam is judged to be in fair condition. Based on the size and hazard classification of the dam, the recommended SDF varies from the 1/2 PMF to the PMF. The PMF is selected as the SDF for Lake Watawga Dam based on the downstream conditions. The existing spillway can pass only about 14 percent of the PMF. It is judged that the dam would fail during the PMF. Failure of Lake Watawga Dam would cause an increased hazard for loss of life. Based on criteria established for these studies, the spillway capacity is rated as seriously inadequate.

(2) Deficiencies exist that are considered to be indicative of potential stability problems for the spillway.

(3) There is no functional outlet works at the dam. The condition of the abandoned outlet works is unknown.

(4) Maintenance of the dam is inadequate.

(5) A summary of the features and observed deficiencies is listed below:

Feature and Location	Observed Deficiency
Embankment:	Irregular profile; local deterioration of exposed corewall; brush and one tree.
Spillway:	Concrete apron cracked; piece of apron missing; deterioration of sidewalls; mortar and stones missing from wall at end of apron; possible voids under apron; right wingwall damaged and overgrown with brush.

Feature and Location	Observed Deficiency
Outlet Works:	No functional outlet works.

b. Adequacy of Information. The information available is such that a preliminary assessment of the condition of the dam can be inferred from the combination of visual inspection, past performance, and computations performed as part of this study.

c. Urgency. The recommendations in Paragraph 7.2 should be implemented without delay.

d. Necessity for Further Investigations. In order to accomplish the remedial measures outlined in Paragraph 7.2, further investigations by the Owner will be required.

7.2 Recommendations and Remedial Measures.

a. The following studies and remedial measures are recommended to be undertaken by the Owner, in approximate order of priority, immediately:

(1) Perform additional studies to more accurately ascertain the spillway capacity required for Lake Watawga Dam as well as the nature and extent of measures required to provide adequate spillway capacity. Take appropriate action as required.

(2) Perform additional studies as required to determine whether any potential hazard to stability exists for the spillway.

(3) Take action as required to provide a functional outlet works at the dam.

(4) Design and construct repairs for the deteriorated areas of the various structures.

(5) Remove brush and trees growing on and near the embankment.

All investigations, studies, designs, and inspection of construction should be performed by a professional engineer experienced in the design and construction of dams. Tree removal should also be performed under the guidance of a professional engineer.

b. In addition, the Owner should institute the following operational and maintenance procedures:

(1) Develop a detailed emergency operation and warning system for the dam.

(2) During periods of unusually heavy rains, provide round-the-clock surveillance of the dam.

(3) When warnings of a storm of major proportions are given by the National Weather Service, the Owner should activate his emergency operation and warning system.

(4) Initiate an inspection program such that the dam is inspected on a regular basis. As presently required by the Commonwealth, the inspection program should include a formal annual inspection by a professional engineer experienced in the design and construction of dams. Utilize the inspection results to determine if remedial measures are necessary.

(5) Institute a maintenance program so that all features of the dam are properly maintained.

APPENDIX A

CHECKLIST - ENGINEERING DATA

CHECKLIST

ENGINEERING DATA

DESIGN, CONSTRUCTION, AND OPERATION
PHASE I

NAME OF DAM: Lake Watawga Dam

NDI ID NO.: PA-00098 DER ID NO.: 64-38

Sheet 1 of 4

ITEM	REMARKS
AS-BUILT DRAWINGS	None.
REGIONAL VICINITY MAP	See Plate E-1.
CONSTRUCTION HISTORY	Constructed about 1907. Reconstructed 1915. Fill material added to slopes at unknown date. Repairs after 1955 Flood. Repairs to corewall and spillway walls 1970.
TYPICAL SECTIONS OF DAM	None.
OUTLETS: Plan Details Constraints Discharge Ratings	No details available.

A-1

ENGINEERING DATA

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	None.
DESIGN REPORTS	Brief description of features in 1917 report prepared by Pennsylvania Water Supply Commission.
GEOLOGY REPORTS	None.
DESIGN COMPUTATIONS: Hydrology and Hydraulics Dam Stability Seepage Studies	None.
MATERIALS INVESTIGATIONS: Boring Records Laboratory Field	None.
POSTCONSTRUCTION SURVEYS OF DAM	None.

ENGINEERING DATA

ITEM	REMARKS
BORROW SOURCES	Unknown.
MONITORING SYSTEMS	None.
MODIFICATIONS	Reconstructed 1917 (extent of work unknown); embankment material added at unknown time; minor modification of spillway 1970.
HIGH POOL RECORDS	None.
POSTCONSTRUCTION ENGINEERING STUDIES AND REPORTS	None.
PRIOR ACCIDENTS OR FAILURE OF DAM: Description Reports	Minor damage from erosion during August 1955 Flood.

ENGINEERING DATA

ITEM	REMARKS
MAINTENANCE AND OPERATION RECORDS	None.
SPILLWAY: Plan Sections Details	See Plate E-2 in Appendix E.
OPERATING EQUIPMENT: Plans Details	None.
PREVIOUS INSPECTIONS Dates Deficiencies	1919: No deficiencies. 1924: No deficiencies. 1930: Slight seepage below left end of dam. 1935: No deficiencies. 1948: Trees on downstream slope; swampy at toe toward right end. 1952: Slight leakage through concrete wall on left crest. 1956: Slight embankment erosion below wingwall on right end of spillway was repaired (damaged during August 1955 Flood) 1965: Spillway abutments need repairs; possible leakage at spillway abutments; cracks on spillway slab; cracks at downstream face of spillway. 1969: Concrete walls in need of repairs.

APPENDIX B

CHECKLIST - VISUAL INSPECTION

CHECKLIST

VISUAL INSPECTION

PHASE I

Name of Dam: Lake Watauga Dam **County:** Wayne **State:** Pennsylvania

NDI ID No.: PA-00098 **DER ID No.:** 64-38

Type of Dam: Earthfill with Concrete Corewall **Hazard Category:** High

Date(s) Inspection: 3 June 1980 **Weather:** Clear **Temperature:** 75°

Thunderstorm occurred during morning just prior to inspection.

Pool Elevation at Time of Inspection: 1920.1 msl/**Tailwater at Time of Inspection:** 1909.4 msl

Datum based on pool elevation shown on USGS Map.

Inspection Personnel:

A. H. Whitman (GFCC) W. P. Moyer (Lake Watauga Holding Corporation)

D. B. Ebersole (GFCC) A. W. Lapp (Lake Watauga Holding Corporation)

J. T. Chernesky (Penn DER) F. C. Shoenagel Jr. (Owner's Engineer)

D. B. Wilson (GFCC) **Recorder**

EMBANKMENT

Sheet 1 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None apparent.	High grass and weeds covered embankment to left of spillway.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None apparent.	
SLOUGHING OR EROSION: Embankment Slopes Abutment Slopes	None apparent.	
CREST ALIGNMENT: Vertical Horizontal	See Plate E-2 in Appendix E and profile at end of Appendix B.	Top of embankment is lower than top of concrete corewall at several locations.
RIPRAP FAILURES	Limited amount of riprap protection but no evidence of serious erosion.	

EMBANKMENT

Sheet 2 of 2

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT WITH: **Abutment** **Spillway** **Other Features**	No apparent deficiencies.	Ends of dam are difficult to identify because of site conditions.
ANY NOTICEABLE SEEPAGE	None apparent.	Any seepage that might exist at base of spillway would have been obscured by spillway flow.
STAFF GAGE AND RECORDER	None.	
DRAINS	None.	
BRUSH AND TREES	Minor amounts of brush on top of dam near spillway; one tree at downstream toe at right side of spillway.	

CONCRETE COREWALL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
COREWALL - LEFT OF SPILLWAY	Only small portion visible; 6 fine cracks extend across top; areas of local deterioration on upstream face.	Upstream and downstream fills cover most of corewall.
COREWALL - AT SPILLWAY	Corewall at spillway acts as weir. Level of upstream fill at spillway averages 5" lower than top of corewall.	Top of corewall in good condition at spillway.
COREWALL - RIGHT OF SPILLWAY	Only small portion visible; areas of local deterioration on upstream face.	

UNGATED SPILLWAY

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Corewall acts as weir.	See description on Sheet B-4.
APPROACH CHANNEL	Reservoir area.	No deficiencies.
DISCHARGE CHANNEL	Concrete slab: slab cracked several locations; differential vertical movement at some cracks (approx. 3/4" maximum); piece broken and missing at downstream left corner. Sidewalls: minor deterior. at base; some fine cracks. Downstream Masonry Face: some deep voids detected by probing where facing stones missing. Wingwalls: right wingwall partially collapsed.	General description: conc. slab with low sidewalls is located immediately downstream from corewall. At end of slab is free overfall. The visible face at the free overfall is stone masonry with no mortar apparent. Along each side of channel at overfall is a dry stone masonry wingwall. A private roadway is located 20' downstream from spillway. A timber bridge crosses the outlet channel.

INSTRUMENTATION

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None.	
OBSERVATION WELLS	None.	
WEIRS	None.	
PIEZOMETERS	None.	
OTHER	None.	

DOWNSTREAM CHANNEL

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION: **Obstructions** **Debris** **Other**	Timber bridge and approx. 4' high roadway embankment located 20' downstream.	Would not affect spillway discharge capacity. Would probably wash out during large spillway flows.
SLOPES	Mild slopes; relatively wide valley; partially wooded.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	Approx. 7 low-lying dwellings in first 0.3 mile reach downstream.	

RESERVOIR AND WATERSHED

Sheet 1 of 1

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Mild slopes surround reservoir; no evidence of stability problems.	
SEDIMENTATION	None reported.	
WATERSHED DESCRIPTION	Approx. 95% wooded; minor amount of development; swampy areas common.	

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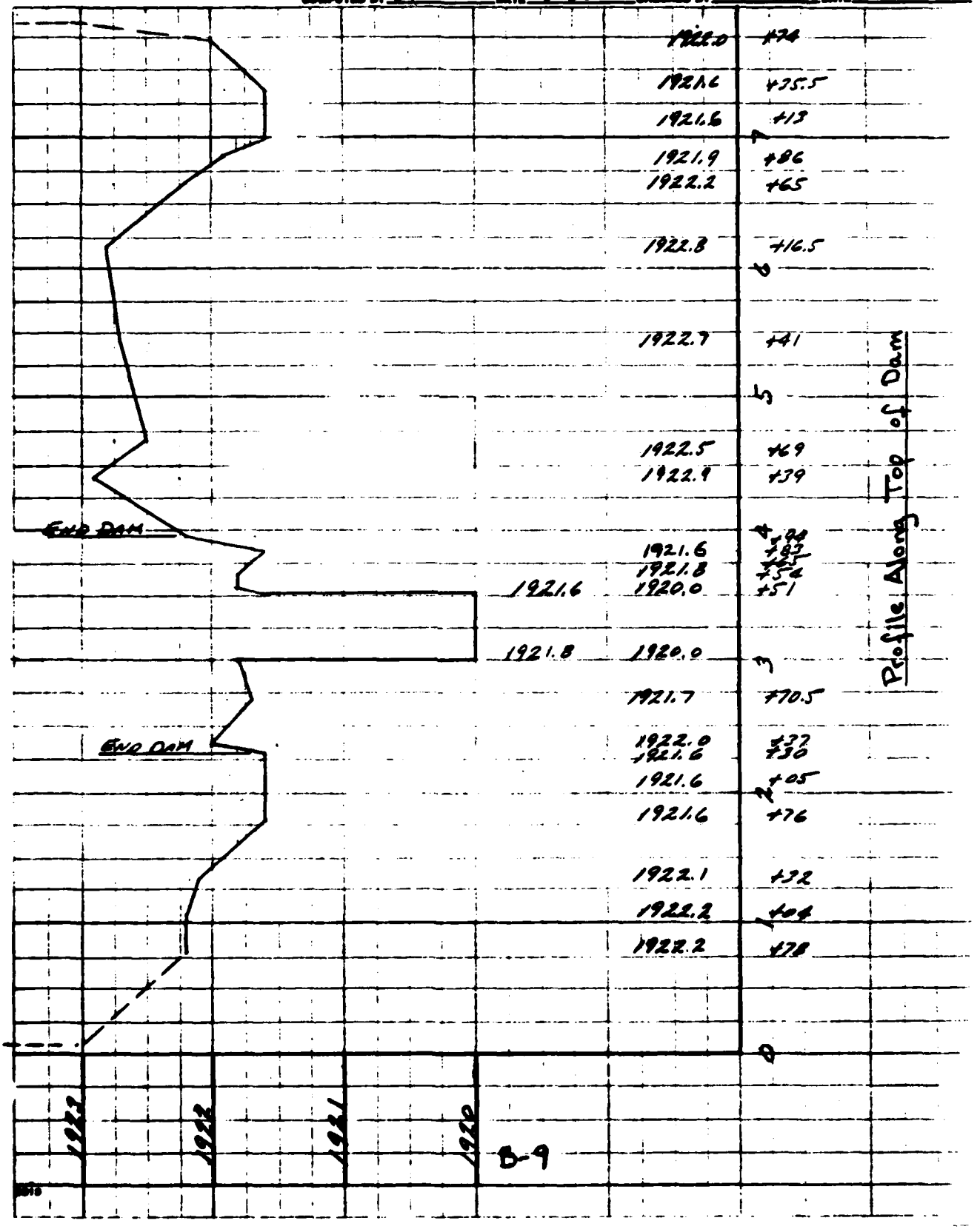
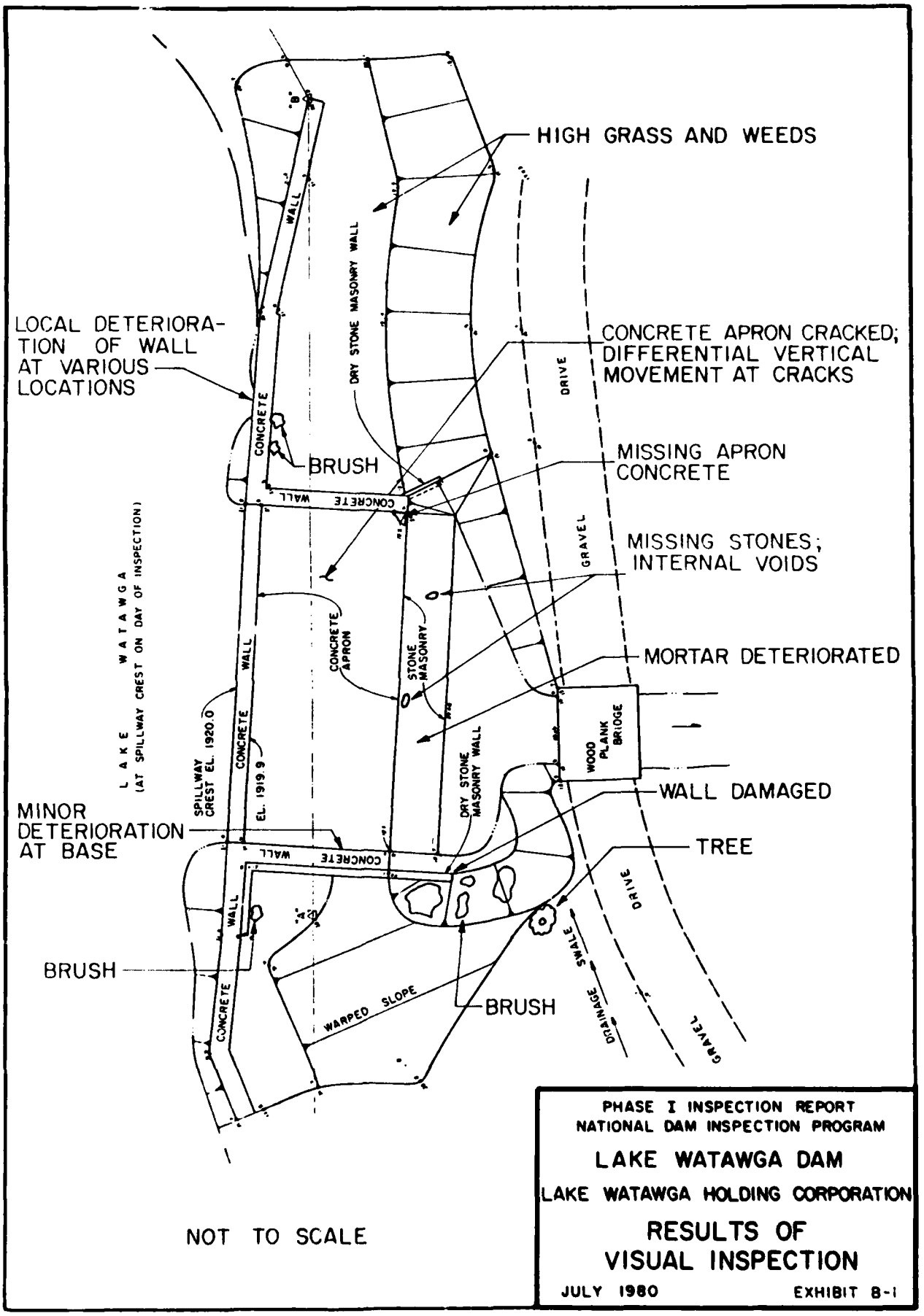
HARRISBURG, PA.

SUBJECT PROFILE - TOP of DAM — FILE NO. 8202
LAKE WATAWGA DAM — SHEET NO. ____ OF ____ SHEETS
FOR
COMPUTED BY DLE — DATE 6-80 — CHECKED BY ____ — DATE ____



	1922.0	+24
	1921.6	+35.5
	1921.6	+13
	1921.9	+86
	1922.2	+65
	1922.8	+16.5
	1922.7	+41
	1922.5	+69
	1922.9	+39
	1921.6	+94
	1921.8	+83
	1921.8	+55
1921.6	1920.0	+54
		+51
1921.8	1920.0	
	1921.7	+70.5
	1922.0	+32
	1921.6	+30
	1921.6	+05
	1921.6	+76
	1922.1	+32
	1922.2	+04
	1922.2	+78

Profile Along Top of Dam



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LAKE WATAWGA DAM

LAKE WATAWGA HOLDING CORPORATION

RESULTS OF VISUAL INSPECTION

JULY 1980 EXHIBIT B-1

APPENDIX C

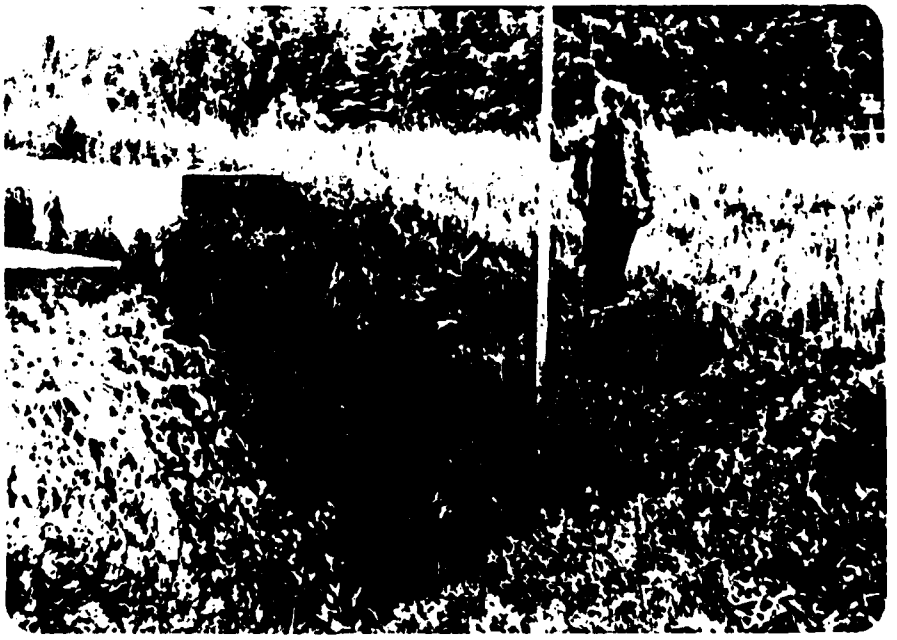
PHOTOGRAPHS

LAKE WATAWGA DAM

A. Top of Dam.

B. Corewall at Left Side of Dam.

C. Corewall at Right End of Dam.



D. Downstream Slope Left of Spillway.

E. Downstream Slope Right of Spillway.

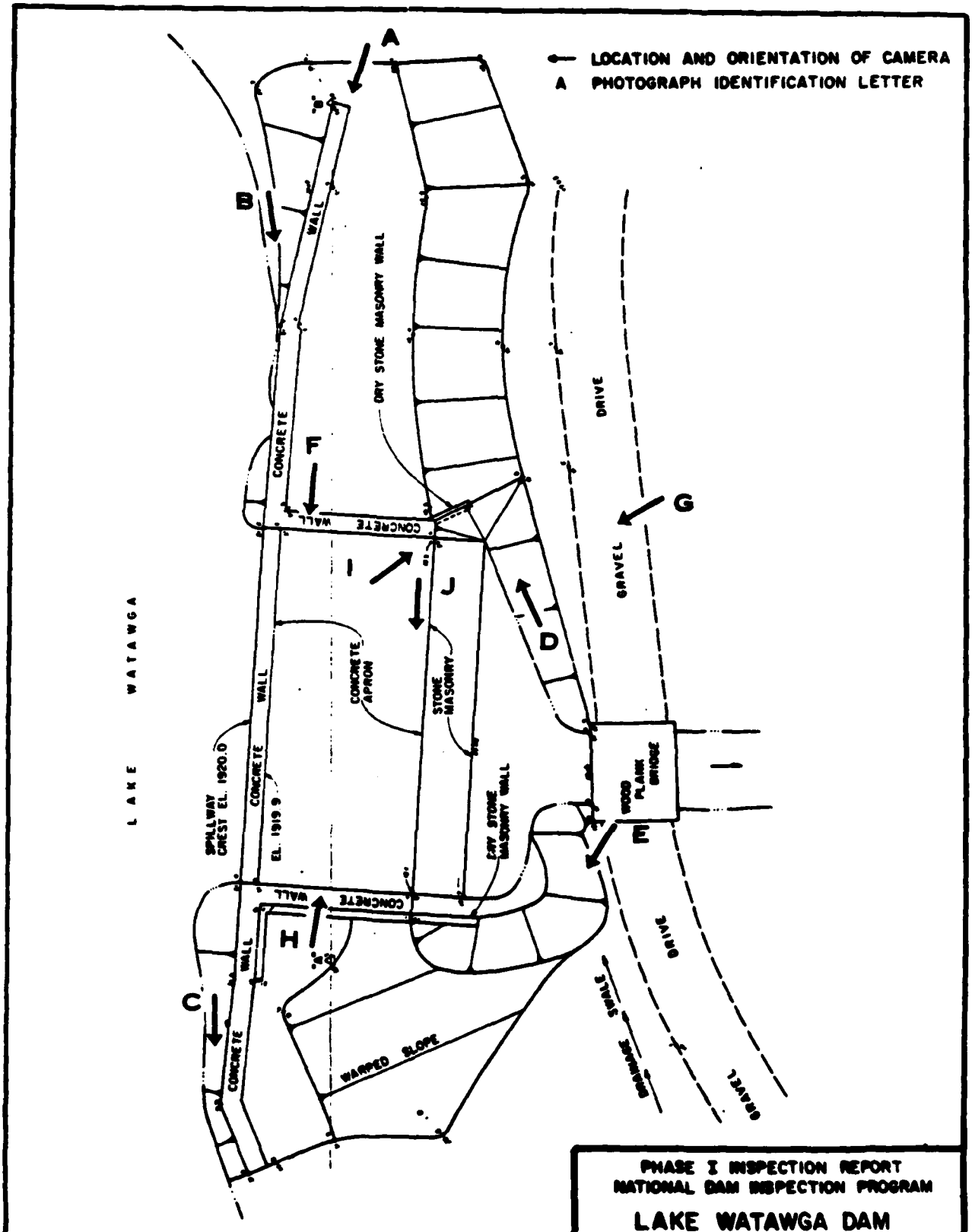
F. Spillway and Right Overbank.

G. Spillway.

H. Concrete Spillway Apron.

I. Missing Concrete on Spillway Apron.

J. Missing Stone and Void at End of Spillway Apron.



NOT TO SCALE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LAKE WATAWGA DAM

LAKE WATAWGA HOLDING CORPORATION

GUIDE TO LOCATION OF PHOTOGRAPHS

JULY 1980 PLATE C-1

APPENDIX D

HYDROLOGY AND HYDRAULICS

APPENDIX D

HYDROLOGY AND HYDRAULICS

Spillway Capacity Rating:

In the recommended Guidelines for Safety Inspection of Dams, the Department of the Army, Office of the Chief of Engineers (OCE), established criteria for rating the capacity of spillways. The recommended Spillway Design Flood (SDF) for the size (small, intermediate, or large) and hazard potential (low, significant, or high) classification of a dam is selected in accordance with the criteria. The SDF for those dams in the high hazard category varies between one-half of the Probable Maximum Flood (PMF) and the PMF. If the dam and spillway are not capable of passing the SDF without overtopping failure, the spillway capacity is rated as inadequate. If the dam and spillway are capable of passing one-half of the PMF without overtopping failure, or if the dam is not in the high hazard category, the spillway capacity is not rated as seriously inadequate. A spillway capacity is rated as seriously inadequate if all of the following conditions exist:

(a) There is a high hazard to loss of life from large flows downstream of the dam.

(b) Dam failure resulting from overtopping would significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure.

(c) The dam and spillway are not capable of passing one-half of the PMF without overtopping failure.

Description of Model:

If the Owner has not developed a PMF for the dam, the watershed is modeled with the HEC-1DB computer program, which was developed by the U.S. Army Corps of Engineers. The HEC-1DB computer program calculates a PMF runoff hydrograph (and percentages thereof) and routes the flows through both reservoirs and stream sections. In addition, it has the capability to simulate an overtopping dam failure. By modifying the rainfall criteria, it is also possible to model the 100-year flood with the program.

APPENDIX D

Delaware River Basin
Name of Stream: Tributary to Lehigh River
Name of Dam: Lake Wataunga Dam
NDI ID No.: PA-00098
DER ID No.: 64-38
Latitude: 41° 14' 20" Longitude: 75° 26' 40"
Top of Dam Elevation: 1921.6
Streambed Elevation: 1909.4 Height of Dam: 12.2 ft
Reservoir Storage at Top of Dam Elevation: 654 acre-ft
Size Category: Small
Hazard Category: High (see Section 5)
Spillway Design Flood: SDF varies from ½ PMF to PMF; Recommend PMF based on size and downstream conditions.

UPSTREAM DAMS

Name	Distance from Dam (miles)	Height (ft)	Storage at top of Dam Elevation (acre-ft)	Remarks
No Upstream Dams				

DOWNSTREAM DAMS

Gouldsboro Dam	1.5	12		DER I.D. 35-30; on USGS as Johnson Pond
Lake Lehigh Dam	2.2	10		DER I.D. 64-51; on USGS as Western Pond

Delaware River Basin

Name of Stream: Tributary to Lehigh River

Name of Dam: Lake Wotawga Dam

DETERMINATION OF PMF RAINFALL & UNIT HYDROGRAPH

UNIT HYDROGRAPH DATA:

Sub-area	Drainage Area (square miles)	Cp (1)	Ct (2)	L miles (3)	L_{ca} miles (4)	L' miles (5)	Tp hours (6)	Map Area (7)	Plate (8)
A-1	2.57	0.45	2.1	2.08	0.61	—	2.26	2	B
Total	2.57								

(See Sketch on Sheet D-4)

(1) & (2): Snyder Unit Hydrograph coefficients supplied by Baltimore District, Corps of Engineers on maps and plates referenced in (7) & (8)

The following are measured from the outlet of the subarea:

(3): Length of main watercourse extended to divide

(4): Length of main watercourse to the centroid

The following is measured from the upstream end of the reservoir at normal pool:

(5): Length of main watercourse extended to divide

(6): $Tp=C_t \times (L \times L_{ca})^{0.3}$, except where the centroid of the subarea is located in the reservoir. Then $Tp=C_t \times (L')^{0.6}$

Initial flow is assumed at 1.5 cfs/sq. mile

Computer Data: QRCSN = -0.05 (5% of peak flow)
RTIOR = 2.0

RAINFALL DATA:

PMF Rainfall Index= 22.0 in., 24 hr., 200 sq. mile

	Hydromet. 40 (Susquehanna Basin)	Hydromet. 33 (Other Basins)
Zone:	N/A	1
Geographic Adjustment Factor:	N/A	1.0
Revised Index Rainfall:	N/A	22.0

RAINFALL DISTRIBUTION (percent)

Time	Percent
6 hours	111
12 hours	123
24 hours	133
48 hours	142
72 hours	—
96 hours	—

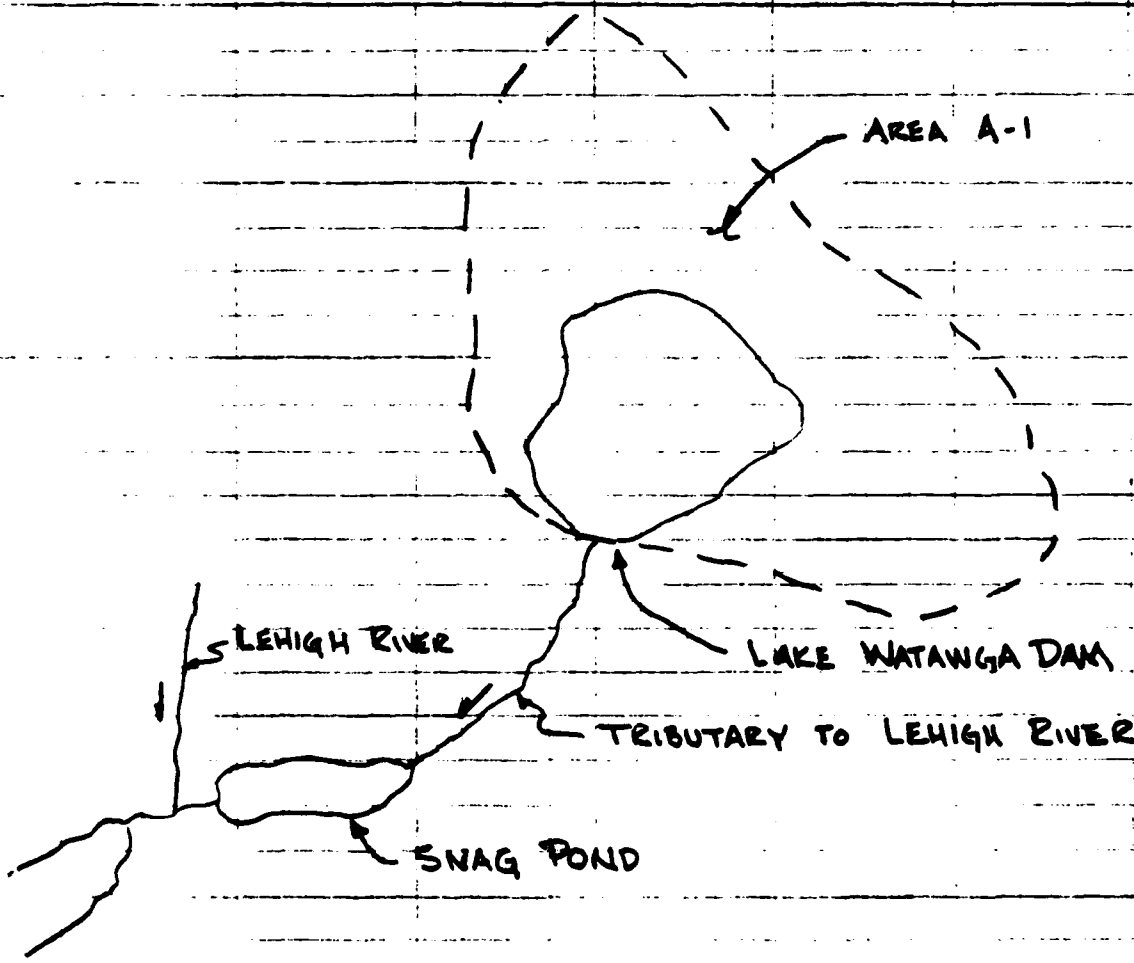
GANNETT FLEMING CORDDRY AND CARPENTER, INC.
HARRISBURG, PA.

SUBJECT _____ FILE NO. _____

SHEET NO. _____ OF _____ SHEETS

FOR _____

COMPUTED BY _____ DATE _____ CHECKED BY _____ DATE _____



LAKE WATAWGA DAM
SKETCH OF SYSTEM

NOT TO SCALE

Data for Dam at Outlet of Subarea A-1

Name of Dam: Lake Watauga Dam

SPILLWAY DATA:	Existing Conditions	Design Conditions
Top of Dam Elevation	1921.6	N/A
Spillway Crest Elevation	1920.0	N/A
Spillway Head Available (ft)	1.6	N/A
Type Spillway	Concrete Weir - Free Overfall	
"C" Value - Spillway	3.1	N/A
Crest Length - Spillway (ft)	51.0	N/A
Spillway Peak Discharge (cfs)	320	N/A
Auxiliary Spillway Crest Elev.		
Auxiliary Spill. Head Avail. (ft)		
Type Auxiliary Spillway		
"C" Value - Auxiliary Spill. (ft)		
Crest Length - Auxil. Spill. (ft)	N/A	N/A
Auxiliary Spillway Peak Discharge (cfs)		
Combined Spillway Discharge (cfs)		

Spillway Rating Curve: $Q = (3.1)(51)H^{3/2}$

Elevation	Q Spillway (cfs)	Q Auxiliary Spillway (cfs)	Combined (cfs)

OUTLET WORKS RATING:	Outlet 1	Outlet 2	Outlet 3
Invert of Outlet			
Invert of Inlet			
Type			
Diameter (ft) = D			
Length (ft) = L			
Area (sq. ft) = A			
N			
K Entrance			
K Exit			
K Friction=$29.1N^2L/R^{4/3}$			
Sum of K			
$(1/K)^{0.5} = C$			
Maximum Head (ft) = HM			
$Q = CA\sqrt{2g(HM)}$ (cfs)			
Q Combined (cfs)			

No Outlet Works

Data for Dam at Outlet of Subarea A-1 (See sketch on Sheet D-4)

Name of Dam: Lake Watauga Dam

STORAGE DATA:

Elevation	Area (acres)	Storage million gals	Storage acre-ft		Remarks
1909.4 =ELEV0	0	0	0	*	Streambed
1920.0 =ELEV1	125 =A1	144	442	=S1 *	Normal Pool
1921.6	140	213	654		Top of Dam
1940.0 **	376				

* $S1 = \frac{A1 (ELEV1 - ELEV0)}{3}$

** Planimetered contour at least 10 feet above top of dam

Reservoir Area at Normal Pool is 8 percent of subarea watershed.

BREACH DATA: See next sheet for breach assumptions and data.

See Appendix B for sections and existing profile of the dam.

Soil Type from Visual Inspection: _____

Maximum Permissible Velocity (Plate 28, EM 1110-2-1601) _____ fps
(from $Q = CLH^{3/2} = V \cdot A$ and depth = (2/3) x H) & A = L·depth

HMAX = $(4/9\ V^2/C^2)$ = _____ ft., C = ____ Top of Dam El.= ____

HMAX + Top of Dam El. = _____ = FAILEL
(Above is elevation at which failure would start)

Dam Breach Data:

BRWID = _____ ft (width of bottom of breach)
Z = _____ (side slopes of breach)
ELBM = _____ (bottom of breach elevation, minimum of zero storage elevation)
WSEL = _____ (normal pool elevation)
T FAIL= _____ mins = _____ hrs (time for breach to develop)

Breach Analysis Data

Breach Assumptions:

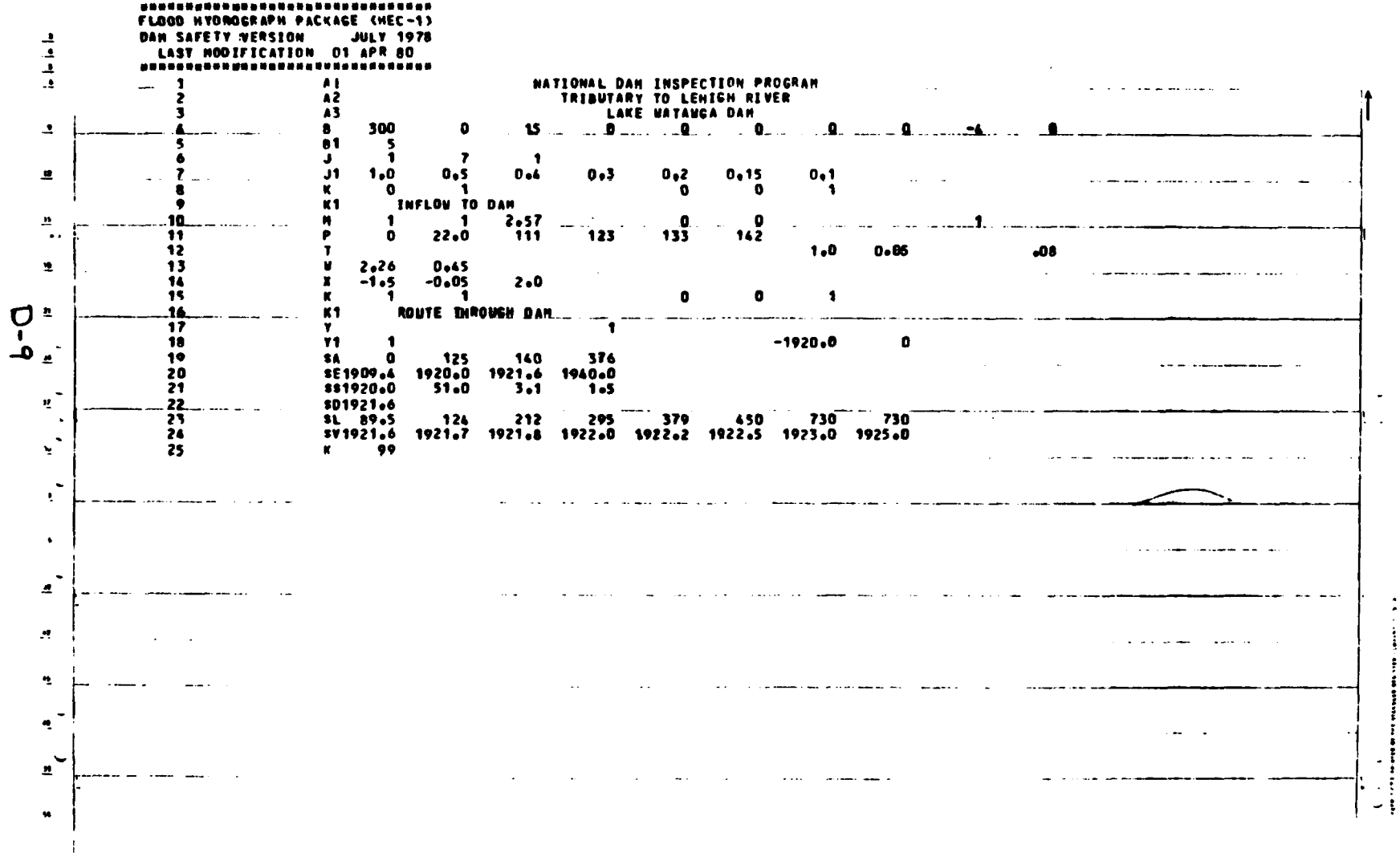
1. Failure is assumed to occur by progressive erosion of soil on the downstream side of the corewall or by erosion around the left end of the dam.
2. It is assumed that the rate of erosion and the time to complete failure would be approximately the same with or without the corewall.
3. Failure is assumed to be initiated at pool elev. 1922.0, which is 0.4 foot above the elevation at the left end of the dam and 0.3 foot above the corewall.
4. Because erosion could cause a washout of the spillway structure, the bottom of breach elevation is assumed to be the streambed elevation at the toe of the dam.

Dam Breach Data*

FAILEL = 1922.0
BRWID = 30.0 ft.
Z = 1
ELBM = 1909.4
WSEL = 1920.0
TFAIL = 0.1 hr.

* See Sht. D-6 for definition of breach parameters.

Selected Computer Output



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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
**********
    1                A1                    NATIONAL DAM INSPECTION PROGRAM
    2                A2                      TRIBUTARY TO LEHIGH RIVER
    3                A3                          LAKE WATAWGA DAM
    4                B     300       0      15       0       0       0       0       0      -4       0
    5                B1      5
    6                J       1       7       1
    7                J1    1.0     0.5     0.4     0.3     0.2    0.15     0.1
    8                K       0       1                       0       0       1
    9                K1        INFLOW TO DAM
   10                M       1       1    2.57                       0       0                       1
   11                P       0    22.0     111     123     133     142
   12                T                                                       1.0    0.06                .08
   13                W    2.26    0.45
   14                X    -1.5   -0.05     2.0
   15                K       1       1                       0       0       1
   16                K1        ROUTE THROUGH DAM
   17                Y                               1
   18                Y1      1                                               -1920.0       0
   19                SA      0     125     140     376
   20                SE1909.4  1920.0  1921.6  1940.0
   21                SS1920.0    51.0     3.1     1.5
   22                SD1921.6
   23                SL   89.5     124     212     295     379     450     730     730
   24                SV1921.6  1921.7  1921.8  1922.0  1922.2  1922.5  1923.0  1925.0
   25                K      99
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS						
				RATIO 1 1.00	RATIO 2 .50	RATIO 3 .40	RATIO 4 .30	RATIO 5 .20	RATIO 6 .15	RATIO 7 .10
HYDROGRAPH AT	1	2.57	1	6763.	3382.	1905.	1429.	953.	715.	476.
	(	6.66)	(	134.68)(	67.44)(	53.95)(	40.47)(	26.98)(	20.23)(	13.48)(
ROUTED TO	1	2.57	1	6620.	2186.	1669.	1141.	600.	360.	214.
	(	6.66)	(	130.83)(	61.89)(	47.25)(	32.32)(	16.98)(	10.19)(	6.11)(

D-10

SUMMARY OF DAM SAFETY ANALYSIS

LAKE WATAWGA DAM

PLAN 1 ..... INITIAL VALUE SPILLWAY CREST TOP OF DAM

ELEVATION	1920.00	1920.00	1921.60
STORAGE	442.	442.	654.
OUTFLOW	0.	0.	320.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	1923.54	1.96	944.	4620.	18.25	42.50	0.00
.50	1922.87	1.27	839.	2184.	14.00	43.00	0.00
.40	1922.67	1.07	808.	1669.	12.50	43.25	0.00
.30	1922.40	.80	769.	1141.	10.75	43.75	0.00
.20	1922.02	.42	713.	600.	7.75	44.75	0.00
.15	1921.70	.10	667.	360.	4.00	45.25	0.00
.10	1921.23	0.00	603.	216.	0.00	46.00	0.00

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
 LAST MODIFICATION  01 APR 80
**********************************

  1      A1                 NATIONAL DAM INSPECTION PROGRAM
  2      A2                   TRIBUTARY TO LEHIGH RIVER
  3      A3                       LAKE NATANGA DAM
  4      B    300      0     15      0      0      0      0      0     -4      0
  5      B1     5
  6      J      2      1      1
  7      J1   0.5
  8      K      0      1                    0      0      1
  9      K1        INFLOW TO DAM
 10      M      1      1   2.57             0      0                    1
 11      P      0   22.0    111    123    133    142
 12      T                                             1.0   0.05           .08
 13      W   2.26   0.45
 14      X   -1.5  -0.05    2.0
 15      K      1      1                    0      0      1
 16      K1        ROUTE THROUGH DAM
 17      Y                           1      1
 18      Y1     1                                  -1920.0      0
 19      SA     0    125    140    376
 20      SE1909.4 1920.0 1921.6 1940.0
 21      SS1920.0   51.0    3.1    1.5
 22      SD1921.6
 23      SL  89.5    126    212    295    379    450    730    730
 24      SV1921.6 1921.7 1921.8 1922.0 1922.2 1922.5 1923.0 1925.0
 25      SB  30.0      1 1909.4    0.1 1920.0 1925.0
 26      SB  30.0      1 1909.4    0.1 1920.0 1922.0
 27      K      1      2                    0      0      1
 28      K1        ROUTE TO DAMAGE CENTER  0.2 MILE DOWNSTREAM
 29      Y                           1      1
 30      Y1     1                                      -1
 31      Y6    .1    .07     .1   1892   1920    900    .02
 32      Y7     0   1920    480   1900    500   1900    505   1892    520   1892
 33      Y7   525   1900    675   1900   1125   1920
 34      K     99
```

SUMMARY OF DAM SAFETY ANALYSIS

LAKE WATAWGA DAM

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1920.00	1920.00	1921.60
STORAGE	442.	442.	654.
OUTFLOW	0.	0.	320.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	1922.87	1.27	830.	2184.	14.00	43.00	0.00

PLAN 2 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1920.00	1920.00	1921.60
STORAGE	442.	442.	654.
OUTFLOW	0.	0.	320.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	1922.11	.51	726.	6146.	1.25	40.85	40.75

PLAN 1 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	2184.	1901.0	43.00

PLAN 2 STATION 2

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.50	5986.	1903.3	41.25

Lake Wetawga Dam
Summary of Pertinent Results

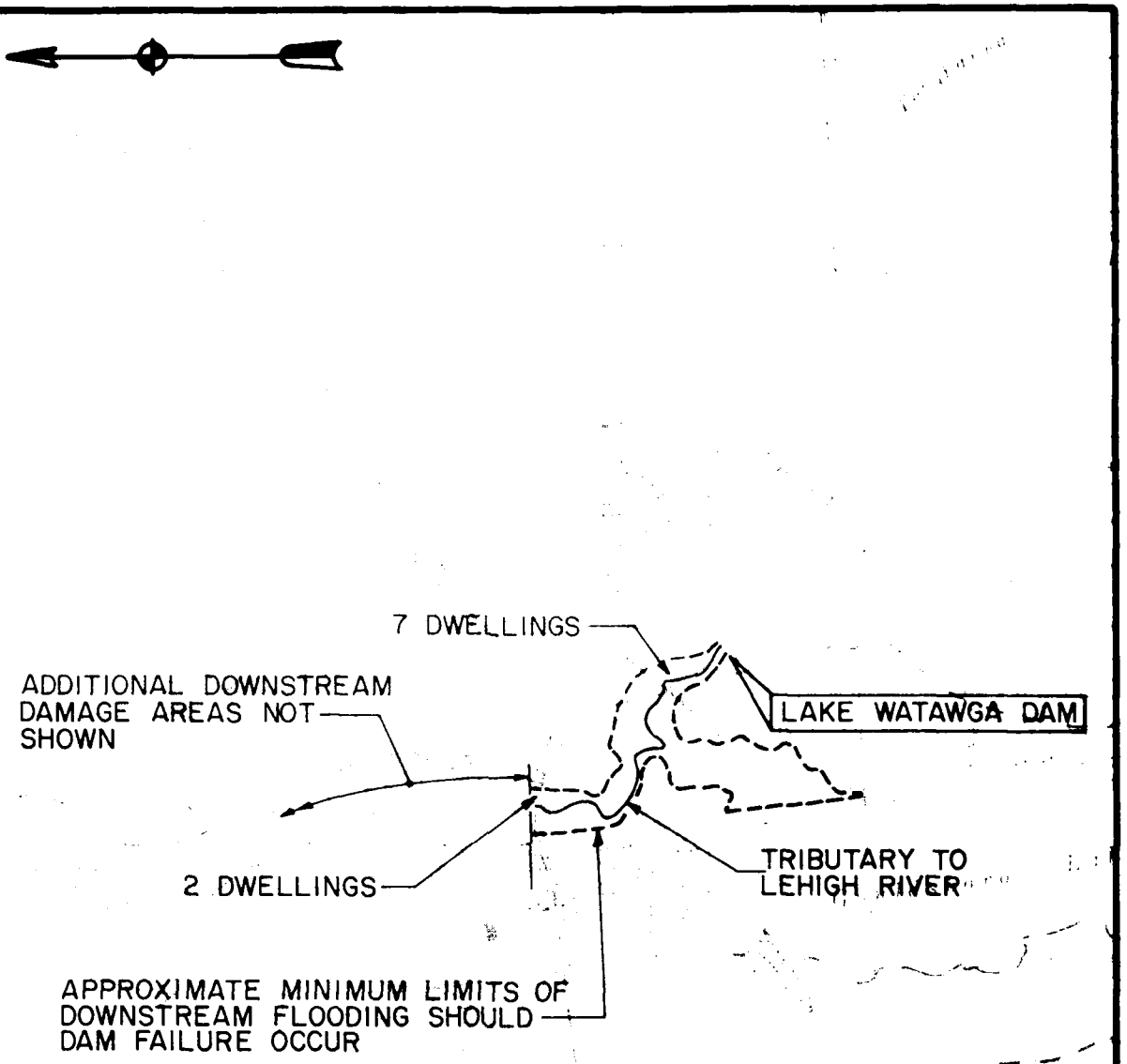
PMF Rainfall = 24.99 inches

Multi-ratio Analysis

	PMF	½ PMF
Runoff (inches)	22.8	11.4
Peak Inflow (cfs)	4,763	2,382
Peak Outflow (cfs)	4,620	2,186
Depth of Overtopping (ft)	1.94	1.27
Duration of Overtopping (hr)	18.25	14.00

Breach Analysis (½ PMF)

	No Failure	Failure	Difference
Peak Outflow (cfs)	2,186	6,146	3,960
Stream Depth at Dwellings (ft)	9.0	11.3	2.3



NOTES:

1. LIMITS OF DOWNSTREAM FLOODING ARE ESTIMATES BASED ON VISUAL OBSERVATIONS.
2. CIRCLED NUMBERS INDICATE STATIONS USED IN COMPUTER ANALYSIS.
3. THIS MAP SHOULD NOT BE USED IN CONNECTION WITH THE EMERGENCY OPERATION AND WARNING PLAN.

2000 0 2000

SCALE: 1 IN. = 2000 FT.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LAKE WATAWGA DAM

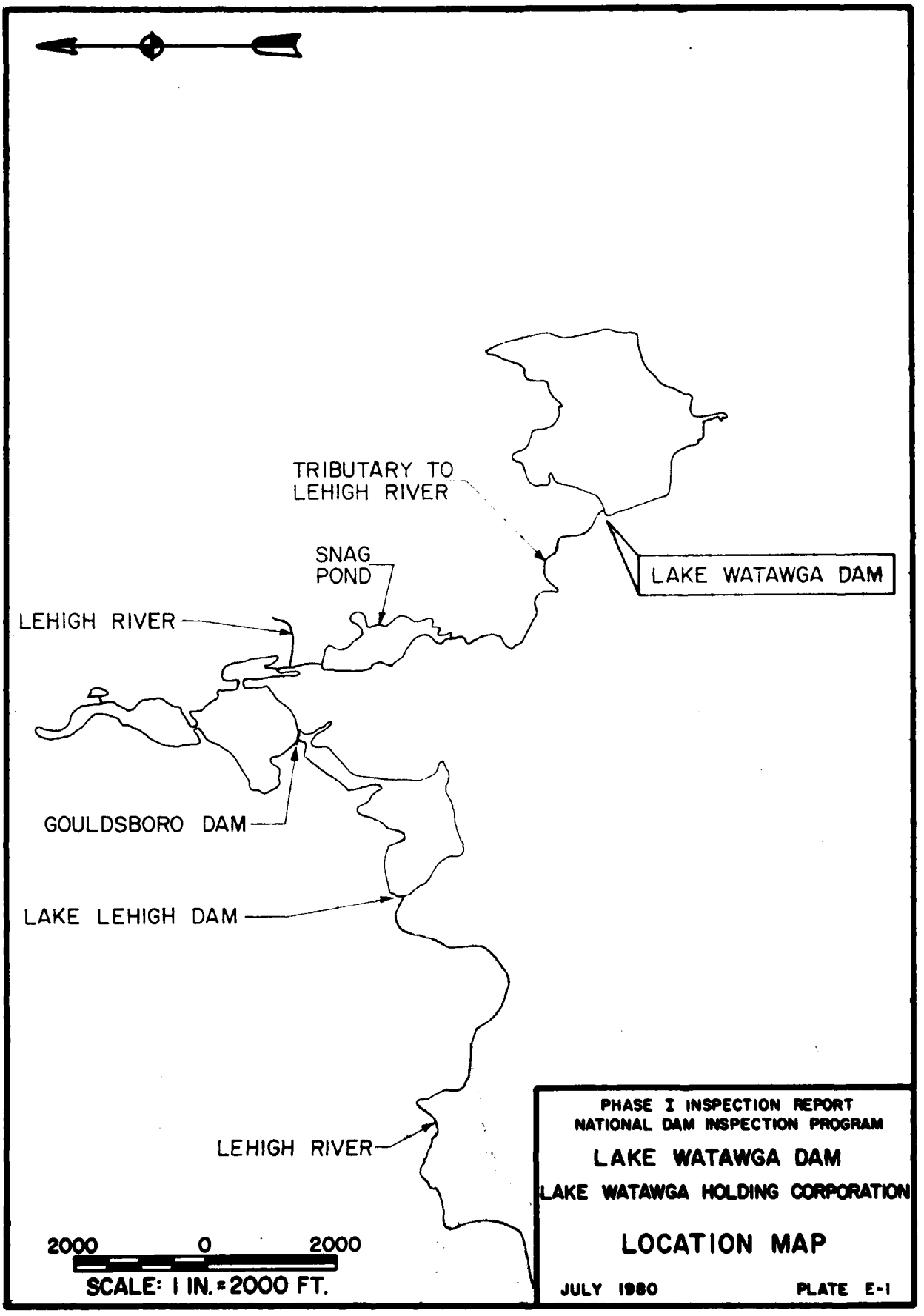
LAKE WATAWGA HOLDING CORPORATION

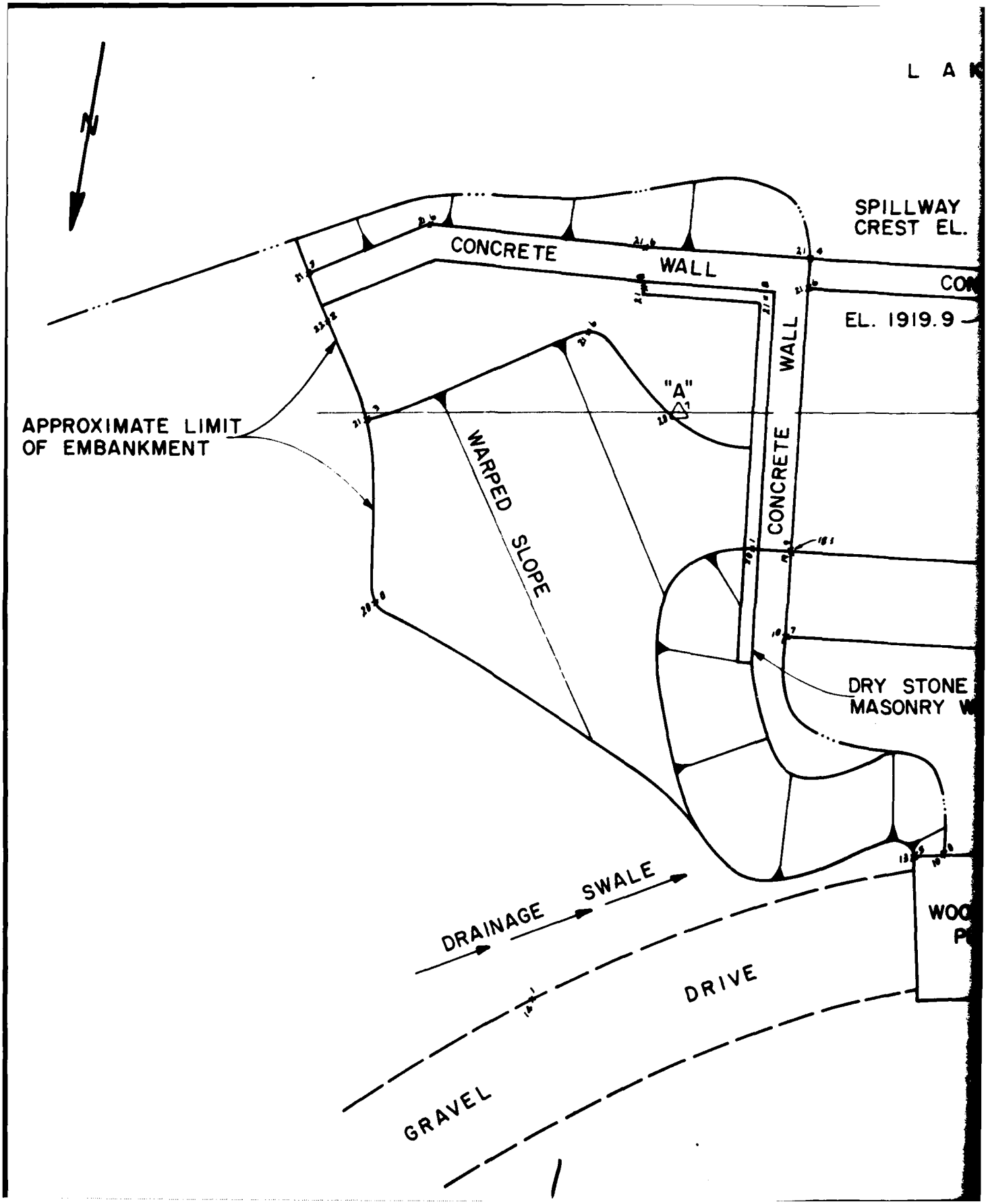
DOWNSTREAM DEVELOPMENT PLAN

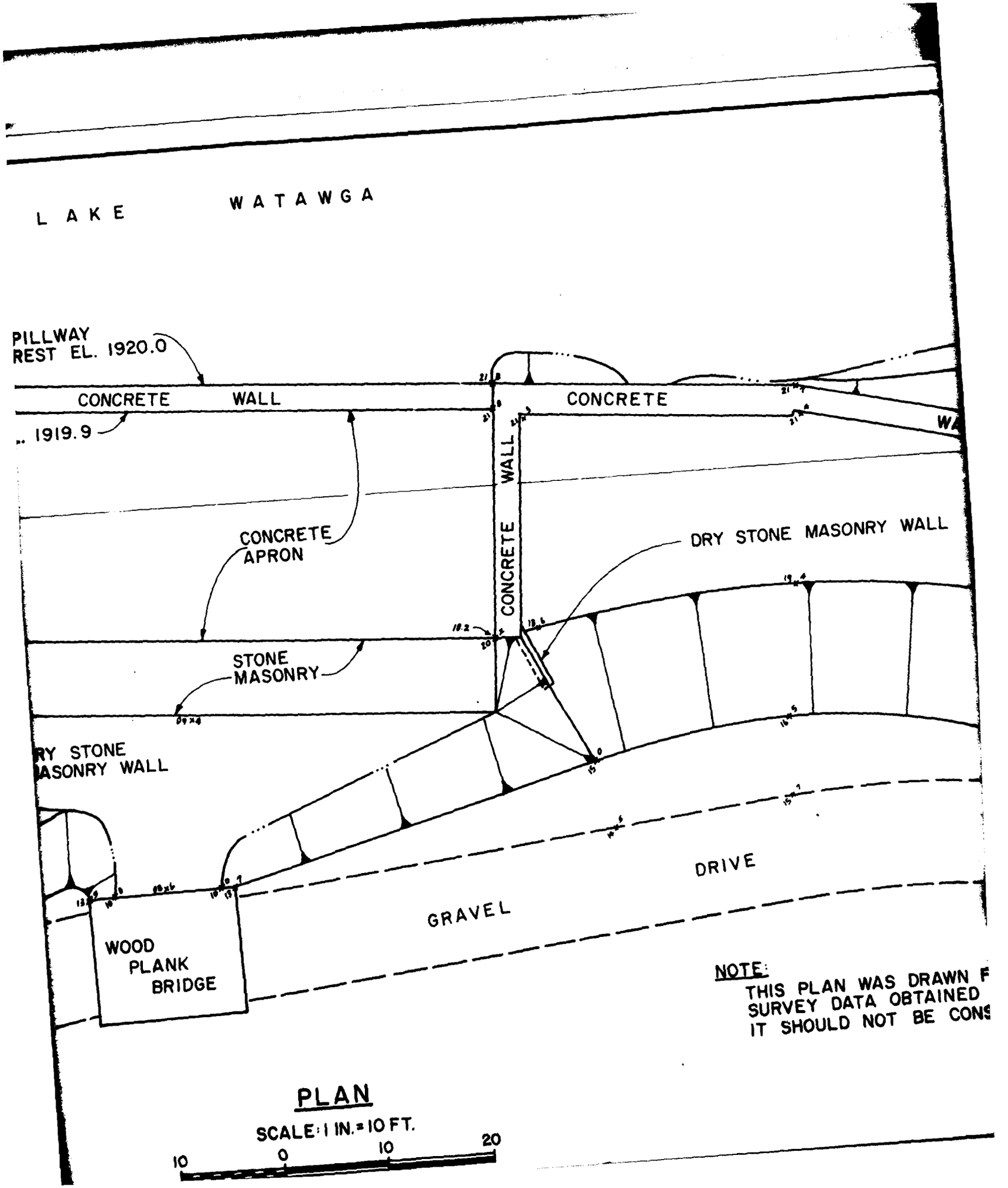
JULY 1980 EXHIBIT D-1

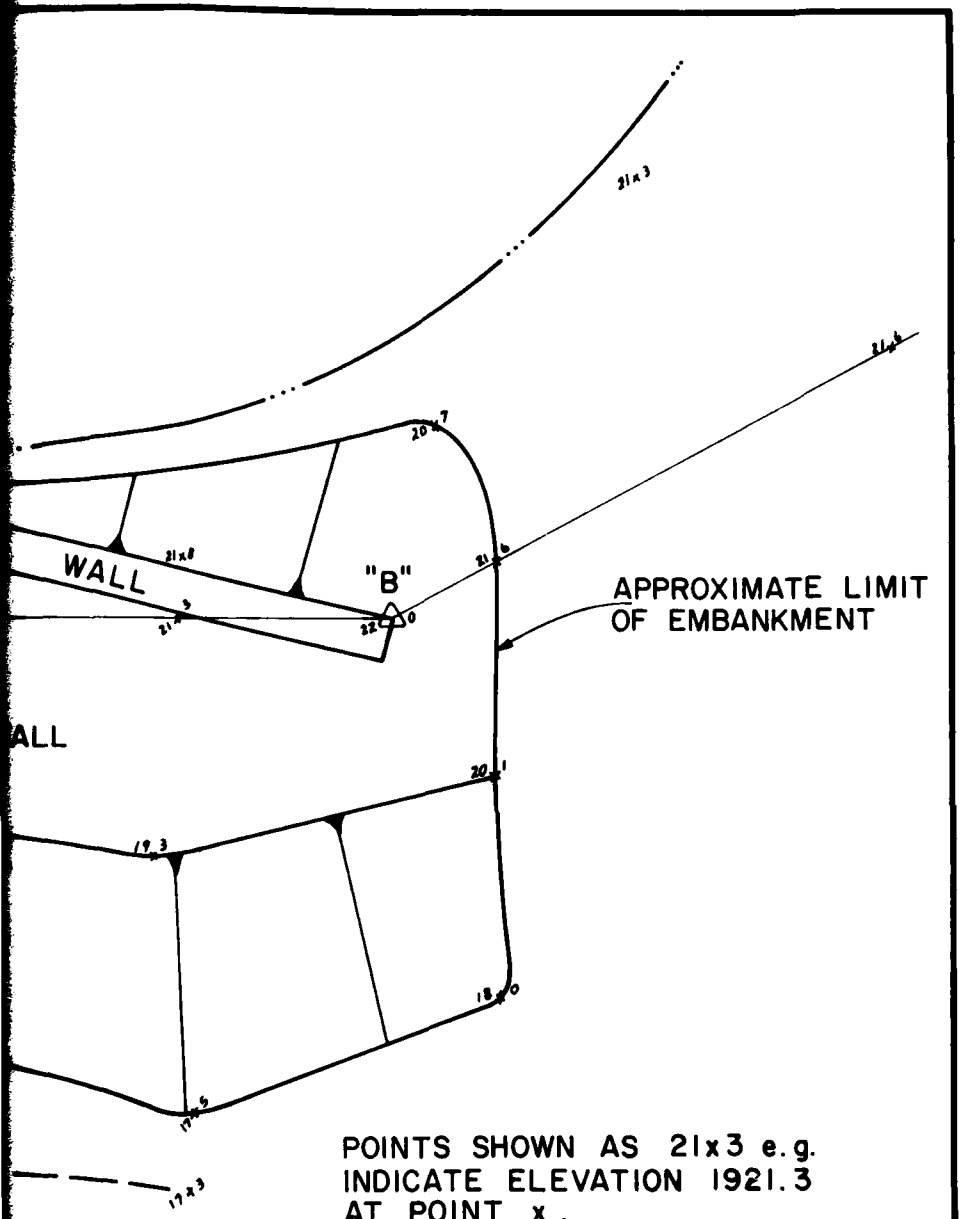
APPENDIX E

PLATES


TRIBUTARY TO
LEHIGH RIVER
SNAG
POND
LAKE WATAWGA DAM
LEHIGH RIVER
GOULDSBORO DAM
LAKE LEHIGH DAM
LEHIGH RIVER
2000 0 2000
SCALE: 1 IN. = 2000 FT.
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
LAKE WATAWGA DAM
LAKE WATAWGA HOLDING CORPORATION
LOCATION MAP
JULY 1980
PLATE E-1


N
SPILLWAY
CREST EL.
CONCRETE
WALL
EL. 1919.9
"A"
APPROXIMATE LIMIT
OF EMBANKMENT
WARPED SLOPE
CONCRETE
WALL
DRY STONE
MASONRY
DRAINAGE
SWALE
DRIVE
GRAVEL


LAKE WATAWGA
PILLWAY
REST EL. 1920.0
CONCRETE WALL
.. 1919.9
CONCRETE
WALL
CONCRETE
APRON
CONCRETE WALL
DRY STONE MASONRY WALL
STONE
MASONRY
RY STONE
ASONRY WALL
DRIVE
GRAVEL
WOOD
PLANK
BRIDGE
NOTE:
THIS PLAN WAS DRAWN F
SURVEY DATA OBTAINED
IT SHOULD NOT BE CONS
PLAN
SCALE: 1 IN. = 10 FT.
10 0 10 20



N FROM LIMITED
ED FOR THIS INSPECTION.
ONSIDERED DEFINITIVE.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LAKE WATAWGA DAM

LAKE WATAWGA HOLDING CORPORATION

PLAN

JULY 1980 PLATE E-2

APPENDIX F

GEOLOGY

LAKE WATAWGA DAM

APPENDIX F

GEOLOGY

Lake Watawga Dam is located in Wayne County within the Appalachian Plateau Physiographic Province. The most pronounced topographic feature in the area is Camelback Mountain, which is part of the Pocono Plateau Escarpment. This escarpment has a well-defined, southwestward trend from Camelback Mountain, but is irregular between Camelback Mountain and Mt. Pocono, which lies to the north. Streams east of the escarpment drain directly to the Delaware River, while those to the west drain to the Lehigh River.

The Pocono Plateau Section lies to the west of the escarpment. This area is relatively flat, with local relief seldom exceeding 100 feet. The topography has been greatly influenced by continental glaciation. Many features were created by deposition of glacial materials. The entire plateau lacks well-developed drainage.

East of the escarpment is the Glaciated Low Plateaus Section of the province. This area is characterized by pre-glacial erosional topography with locally-thick glacial deposits. Local relief is generally 100 to 300 feet.

Bedrock units of the sections described above are the lithified sediments of offshore marine, marginal marine, deltaic environments, and fluvial environments associated with the Devonian Period. These units include siltstones of the Mahantango Formation, siltstones and shales of the Trimmers Rock Formation, and seven mapped members of the Catskill Formation. These members include sandstones, siltstones, and shales of the Towamensing Member; sandstone, siltstone and shales of the Walcksville Member; sandstones, siltstones, and shale of the Beaverdam Run Member; sandstone and shale of the Long Run Member; sandstones and conglomerates in the Packerton Member; sandstone and some conglomerates in the Poplar Gap Member; and sandstones and conglomerates in the Duncannon Member.

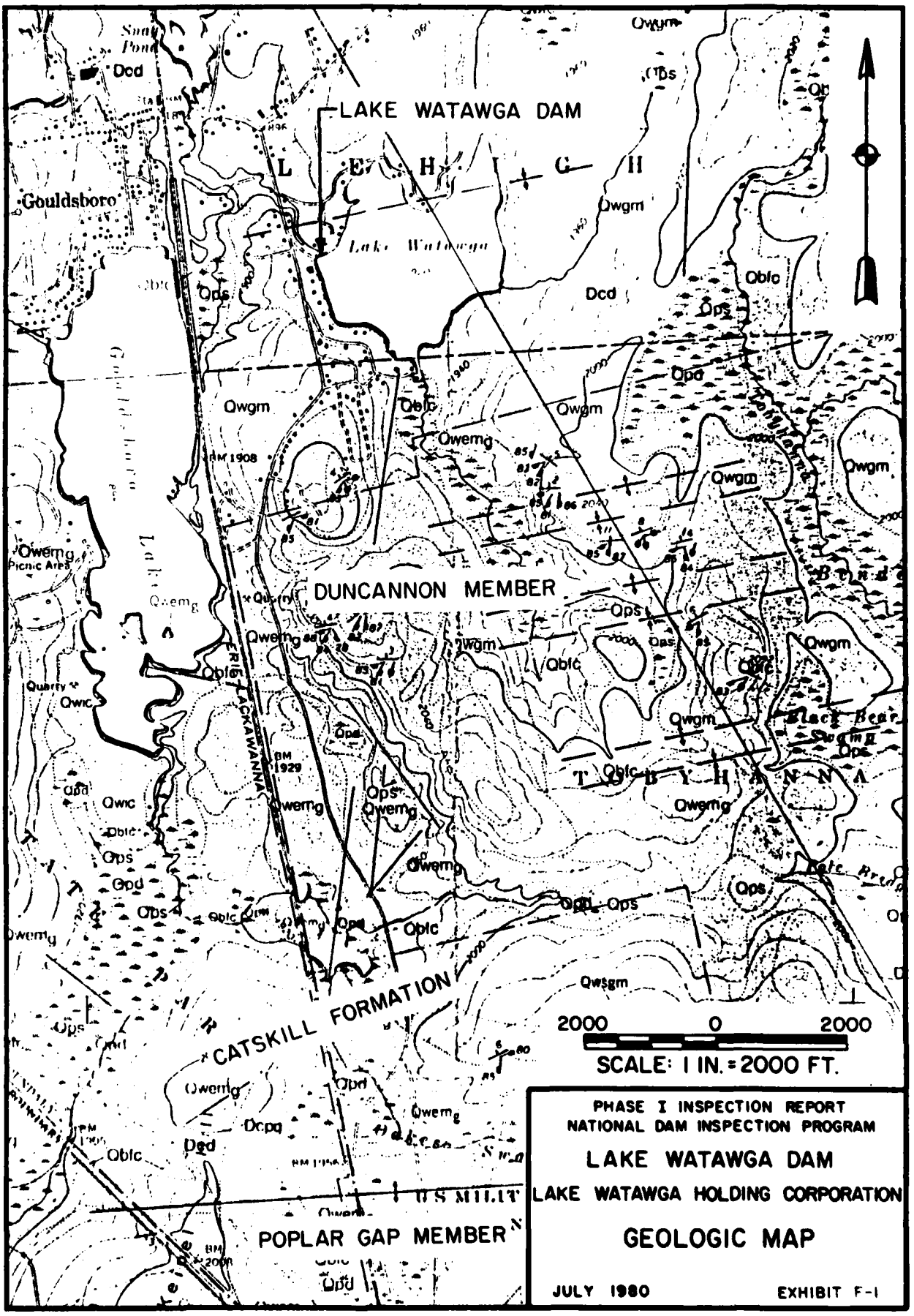
Lake Watawga Dam is underlain by the Duncannon Member of the Catskill Formation. The Duncannon Member is

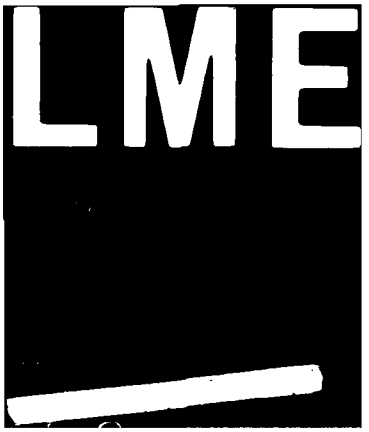
predominantly a conglomerate and sandstone unit with some red siltstone and shale. Conglomerates present are generally thick-bedded with subangular to well-rounded quartz pebbles in a coarse-grained sandstone matrix. They are very well-indurated and have low porosity due to silica cementation. The sandstones are predominantly fine-to medium-grained, thin-to thick-bedded and well-indurated with a clay and silica cement. Red sandstones near the top of the unit grade into red siltstone and shale, marking the contact with the Spechty Kopf Formation.

The Duncannon Member maintains very steep cut slopes. It is reported to be an excellent foundation for heavy structures.

Bedrock is almost entirely overlain by the Gouldsboro End Moraine of Late Wisconsin Age. This material is extremely variable, ranging from till to ice-contact stratified drift. The till has minor clay content and moderate to high porosity and permeability. Boulders up to 8 feet in diameter are common. The drift consists of sand to boulder size material of variable thickness and sorting. Thickness of the moraine ranges from 10 to 95 feet, with an average thickness of 45 feet. Cut slopes in the material are susceptible to failure when loaded or subjected to excessive water. The material has moderate to low foundation support strength.

Available data indicate that the dam is probably founded on the overburden material.


LAKE WATAWGA DAM
Gouldsboro
Lake Watawga
DUNCANNON MEMBER
CATSKILL FORMATION
POPLAR GAP MEMBER
Lackawanna
Picnic Area
Quarry
Owgm
Owemg
Oblc
Ops
Opd
Dcd
Qwsgm
2000 0 2000
SCALE: 1 IN. = 2000 FT.
PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
LAKE WATAWGA DAM
LAKE WATAWGA HOLDING CORPORATION
GEOLOGIC MAP
JULY 1980
EXHIBIT F-1


LME